

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England.....	72	- 3	Missouri Valley.....	57	-15
Middle Atlantic.....	69	- 3	Northern slope.....	57	-10
South Atlantic.....	73	- 2	Middle slope.....	47	-13
Florida Peninsula.....	78	+ 1	Southern slope.....	48	- 7
East Gulf.....	64	- 9	Southern Plateau.....	43	+ 7
West Gulf.....	66	- 6	Middle Plateau.....	52	- 4
Ohio Valley and Tennessee.....	61	-10	Northern Plateau.....	61	- 5
Lower Lakes.....	68	- 8	North Pacific.....	82	+ 7
Upper Lakes.....	71	- 8	Middle Pacific.....	77	+ 3
North Dakota.....	73	- 5	South Pacific.....	73	+ 2
Upper Mississippi Valley.....	63	-10			

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England.....	5.1	- 0.6	Missouri Valley.....	2.8	- 2.9
Middle Atlantic.....	4.1	- 1.6	Northern slope.....	3.9	- 1.5
South Atlantic.....	3.4	- 1.5	Middle slope.....	2.8	- 1.8
Florida Peninsula.....	2.9	- 0.9	Southern slope.....	3.8	- 0.6
East Gulf.....	3.0	- 2.0	Southern Plateau.....	2.7	- 1.0
West Gulf.....	3.4	- 1.7	Middle Plateau.....	4.1	- 0.9
Ohio Valley and Tennessee.....	4.2	- 1.8	Northern Plateau.....	5.2	- 0.6
Lower Lakes.....	4.4	- 2.2	North Pacific.....	6.2	- 0.4
Upper Lakes.....	4.7	- 1.3	Middle Pacific.....	5.6	- 0.2
North Dakota.....	4.3	- 1.6	South Pacific.....	5.0	- 0.8
Upper Mississippi Valley.....	3.1	- 2.6			

RIVERS AND FLOODS.

By Prof. H. C. FRANKENFIELD, in charge River and Flood Division.

At the end of February, 1910, a snow flood was in progress in the Allegheny River, and on the 1st day of March flood stages were general over the lower portion of the river and its tributaries, Pittsburgh reporting the flood stage of 22 feet at 4 p. m., while at Freeport, Pa., the crest stage was 24.6 feet, 4.6 feet above the flood stage at 1 a. m. A second rise of similar character came down from the headwaters a few days later, but as it was not supported by the tributaries, flood stages were not reached below the mouth of the Kiskiminetas River. The flood wave continued down the Ohio River, absorbing on its way considerable additions from all the northern tributaries from the Beaver to the Wabash.

The following table shows the flood stages at the various stations, the crest stages and the dates and times of their occurrence:

Station.	Flood stage.	Crest stage.	Date.	Time.
	Feet.	Feet.		
Pittsburg, Pa.....	22	22.0	1	4 p. m.
Davis Island Dam, Pa.....	25	21.4	1	9 p. m.
Dam No. 2, Pa.....	25	22.8	1	9 p. m.
Beaver Dam, Pa.....	27	34.4	2	3 a. m.
Wheeling, W. Va.....	36	37.4	3	12 noon.
St. Marys, W. Va.....	38	38.0	4	8 a. m.
Marletta, Ohio.....	36	41.2	4	12 noon.
Parkersburg, W. Va.....	36	42.0	4	5 p. m.
Point Pleasant, W. Va.....	39	45.0	5	3 p. m.
Huntington, W. Va.....	50	47.7	6	12 noon.
Cattletown, Ky.....	50	48.9	6	
Portsmouth, Ohio.....	50	50.9	6	8 a. m.
Portsmouth, Ohio.....	50	49.3	6	8 a. m.
Maysville, Ky.....	50	51.8	7	8 a. m.
Cincinnati, Ohio.....	46	41.8	7, 8	
Madison, Ind.....	28	24.3	8	4 p. m.
Louisville, Ky.....	35	39.7	10	8 a. m.
Evansville, Ind.....	35	38.0	10	6 p. m.
Henderson, Ky.....	35	39.8	11	5:30 p. m.
Mount Vernon, Ind.....	35	42.0	12	
Shawneetown, Ill.....	43	36.2	11-13	
Paducah, Ky.....	43	42.2	15	
Cairo, Ill.....	45			

It will be noticed that the differences between the flood crests at Pittsburg and places below were much greater than usual. This was due in largest measure to the great volumes of water from the northern tributaries, those to the southward contributing but little, although the secondary rise from the Allegheny River, and the retardation caused by the elevation of the water plane over the lower 200 miles of the river were of material assistance.

The warnings issued for these floods were of the usual accurate and timely character, and were instrumental in saving a large amount of property. As far as could be learned the losses were about as follows:

District.	Property.	Crops.	Lands.	Suspension of business.	Saved by warnings.
Pittsburg, Pa.....	\$5,000			\$20,000	\$100,000
Parkersburg, W. Va.*					
Cincinnati, Ohio*					
Louisville, Ky.*					
Evansville, Ind.*					
Shawneetown, Ill.	5,000	\$2,000	\$1,000	3,000	50,000
Cairo, Ill.					
Total.....	10,000	2,000	1,000	23,000	150,000

* Nothing of consequence.

The steamer *Virginia* lost her course during the night of March 5-6, and was stranded in a cornfield near Willow Grove, W. Va. She will probably not be floated unless another stage of 45 feet occurs at Point Pleasant, W. Va., during the present season.

Along the interior rivers of the State of Ohio, conditions were very much complicated by ice gorges, and definite forecasts of flood stages were impossible. General warnings were issued frequently, however, and all having property interests were able to take measures to make them secure. Flood stages were reached in all the rivers, and the losses were estimated at about \$1,000,000.

At Defiance, a gorge in the Auglaize River carried away the Francis street highway bridge, causing a loss of \$50,000, and at Napoleon, Ohio, on the Maumee River, the damage amounted to between \$30,000 and \$40,000.

The Wabash River flood was not so serious, although at Mount Carmel, Ill., the river was above the flood stage of 15 feet from March 1 to 13, inclusive, with a crest stage of 21.9 feet on March 9. The losses amounted to about \$6,000, principally of crops.

Nothing of consequence occurred in the Missouri River above Williston, N. Dak. Between Williston and Bismarck, N. Dak., numerous ice gorges had formed, and conditions became so threatening in the vicinity of Bismarck that flood warnings were issued on March 13. At Bismarck the river rose above the flood stage of 14 feet on March 13, reached a crest of 26.4 feet at 2:20 p. m., March 14, and fell below flood stage at 3 p. m., March 16.

Losses were as follows:

Property, exclusive of crops.....	\$100,000
Crops.....	5,000
Lands.....	none.

Total..... 105,000

Property to the amount of at least \$100,000 was saved through the Weather Bureau warnings. The crest of the rise reached Pierre, S. Dak., at 6 p. m., March 18, with a stage of 15 feet, 1 foot above flood stage, and did practically no damage. While the floods below Bismarck were of no great consequence, they were of special interest in that they were the first to afford opportunity for observation and investigation since the organization of the river and flood service in that section. The losses, while considerable in the aggregate, did not fall heavily upon particular communities or individuals, and a large amount of property was saved through the Weather Bureau warnings, the issue of which was greatly hampered by inadequate methods of communication.

The crest stage at Sioux City, Iowa, was reached at 5 p. m., March 20, when the gage read 16.8 feet, 0.2 foot below the flood stage. It has been impossible to obtain any satisfactory estimate of the losses caused by these floods, but judging from the few reports received, the total could not have been less than \$50,000, while the value of property saved through the warnings was probably nearly as much.

The James River flood was most pronounced in the vicinity of Huron, S. Dak., where the river remained above the flood

stage of 9 feet from March 7 to 26, inclusive, with a crest stage of 14.6 feet on March 15. Bottom lands were overflowed to a width of about $1\frac{1}{2}$ miles, but the timely warnings prevented serious damage.

Nothing of interest occurred below Sioux City, although flood stages were experienced as far south as St. Joseph, Mo. At Omaha the crest stage of 19.5 feet, on March 22, 0.5 foot above flood stage, was the highest stage for many years, and some slight damage resulted to property in the bottoms. The rise passed Kansas City on March 24, with a stage of 20.2 feet, 1.8 foot below flood stage, and Hermann, Mo., on March 26, with a stage of 16.4 feet, 4.6 feet below flood stage.

The breaking up of the ice in the Red River of the North was not attended by high water, as the winter snows were very limited in quantity. At Moorhead, Minn., the crest stage on March 18 was 23.2 feet, 2.8 feet below flood stage. The total rise at Wahpeton, N. Dak., was 5 feet; at Caledonia, N. Dak., 11.9 feet; at Moorhead, Minn., 13.8 feet; at Grand Forks, N. Dak., 22.9 feet and at Pembina, N. Dak., 21 feet. At Drayton, N. Dak., a rise of 20 feet was reported on March 21, with a crest stage of 40 feet. This rise was doubtless a temporary one due to an ice gorge.

The Illinois River was generally above flood stage throughout the month, but no damage was reported. Ordinary stages prevailed in the upper Mississippi River, but below Cairo, Ill., there was a decided rise due to the tide from the Ohio River, although flood stages were not reached below Memphis. The crest of the rise passed Cairo on March 15, and reached New Orleans on March 26.

There were also moderate snow floods in the rivers of southern Michigan concurrent with those of the Ohio Valley. Warnings were issued at the proper time for the Grand River watershed, but nothing of special interest occurred. The crest stage at Grand Rapids was 12.5 feet, from 3:30 to 7:00 p. m., March 8, and the river was above the flood stage of 11 feet from March 7 to 10, inclusive. Similar conditions prevailed over the watershed of the Saginaw River where river and flood service has recently been inaugurated.

The warm wave that set in over the eastern portion of the country on February 26, rapidly melted the deep snows and floods of varying character were general in all the northeastern rivers. As a rule conditions were very much complicated by ice gorges, with consequent increased difficulty in forecasting coming stages. Warnings were first issued for the Susquehanna River district at and above Binghamton from February 25 to 28, inclusive, and the results were as forecast.

As a rule the crest stages were from 1 to 3 feet deep above the flood stages and the damage amounted to about \$100,000, while property to the amount of about \$50,000 was saved by the warnings.

By Monday, February 28, all ice remaining in the Susquehanna River and its tributaries below Binghamton and east of Clearfield, Pa., was moving, the gorge at Renovo, Pa., on the West Branch, moving out at 9 a. m., of that day on a 25-foot stage of water. There were, however, no other flood stages reported on the West Branch. On the North Branch higher stages prevailed, especially at Wilkes-Barre, Pa., where the crest stage of 26 feet on March 3, was 6 feet above the flood stage. Flood stages also prevailed from Harrisburg to the mouth of the river, although at Harrisburg the highest stage on March 3 was only 0.2 foot above the flood stage of 17 feet. During the flood several lives were lost at Harrisburg, through carelessness, it is said. Warnings were issued as usual, and the damage in the district above Harrisburg and below Binghamton did not exceed \$25,000, of which \$15,000 was incurred at Wilkes-Barre, and about \$5,000 at Renovo and vicinity. Below Harrisburg, and especially at Port Deposit, Md., the damage was much greater, probably about one-half as much as during the flood of January, 1910, when it was estimated at \$200,000.

Continued high temperatures during the early days of March melted more of the mountain snows, and a light rain fell on March 6. This started another general rise in the North and West branches, and additional warnings of another moderate rise were sent to the North Branch.

In the Mohawk and Hudson valleys and the smaller watersheds of the State of New York the floods were much more serious. They were due mainly to ice gorges and their movements, although the flood volumes were greatly augmented by large quantities of snow water that were brought out by the high temperatures. The Mohawk floods appear to have been most serious in the vicinity of Herkimer and Fort Plain, N. Y. An ice gorge in West Canada Creek was mainly responsible for the flood, which was a backwater one, as the Mohawk waters were not very high at the time. The damage done was of the usual character in time of flood and amounted to about \$100,000. Over other portions of the Mohawk Valley conditions were not so serious.

There was no high water in the Hudson above the mouth of the Mohawk, and that below was caused by ice gorges below Albany. These gorges backed up the water as far as Troy, N. Y., causing stages of 18.3 feet at Albany at 5 a. m., March 2, and at Troy of 21.5 feet at 5 p. m., March 2, flood stages being at 12 and 14 feet, respectively. Warnings of the approach of the high water were issued on February 28 and March 1, and they were of the greatest assistance to the public.

The total losses in the Hudson and Mohawk valleys, exclusive of those sustained through enforced suspension of business, amounted to about \$250,000, while property to the value of \$75,000 was saved by the Weather Bureau warnings. It has been impossible to obtain estimates of the losses occasioned by business suspension, but they were very large, as all freight traffic was interrupted, passenger travel was greatly delayed, and many factories from Utica to Albany were closed for a time.

The floods also extended, in moderate form, into the streams of northern New England without damage of consequence. Warnings for these floods were issued on March 2. The only flood stage in the Connecticut River, resulting from the same general conditions, occurred at Hartford, Conn., at 12 noon, March 3, when the stage was 18.7 feet, 2.6 feet above flood stage. A stage of 16.5 feet, at 10 p. m., March 28, was caused by the melting of the snow that had remained in sheltered places in the valley above.

There were also moderate floods during the early days of the month in the rivers of the South Atlantic States. They were due to general, although not excessive rains, and no losses of consequence resulted, except along the Ocmulgee River where a power plant and some bridges were damaged to the extent of about \$100,000. Timely warnings were issued for all these floods.

A rise of a few feet in the Salt and lower Gila rivers of Arizona was successfully forecast on March 26, and proved of advantage to irrigation and engineering interests.

The same general phenomena of rain and high temperatures that prevailed over the eastern portion of the country during the last few days of February were also experienced at the same time in the northern districts west of the Rocky Mountains, and for the second time within 3 months they were visited by severe floods, accompanied in the mountains by avalanches and landslides that were very destructive to both life and property. On the morning of March 1 an avalanche swept 2 passenger trains into the canyon at the west portal of the Cascade Tunnel at Wellington, Wash., and it is said that over 80 lives were lost. Two days previous another avalanche at Mace, Idaho, in the Coeur d'Alenes, nearly wiped out the little town and destroyed at least a dozen lives.

The floods were general over all the smaller streams of Washington, Idaho, and northern Oregon, as well as in the upper

Snake River, and a description thereof would be but a repetition of the disasters of the early winter. Whitman County, Wash., was probably the chief sufferer, and it is estimated that the losses there were at least \$1,000,000. The losses over the remainder of the State were about as much more. In the vicinity of Caldwell, Idaho, the losses amounted to about \$200,000. These estimates do not include the losses to the railroads, which can not be given at this time. While no regular flood warning service is possible over the greater portion of this district, a general flood warning issued from the local office of the Weather Bureau at Portland, Oreg., on February 26, was of considerable value.

The flood in the Willamette River was, of course, forecast at the proper time, and a large amount of freight was removed from the docks at Portland before the arrival of the flood waters. The flood stages were general from Albany, Oreg., to the mouth of the river, with a crest stage of 19.6 feet, or 4.6 feet above the flood stage at Portland on March 5.

Nothing of interest occurred in the Sacramento watershed except the rapid disappearance of the winter snows, presaging a shortage of water during the coming season.

ICE.

The dates of breaking up of the ice in some of the more important rivers were as follows: Mississippi River, at Fort

Ripley, Minn., on March 14; at Dubuque, Iowa, on March 16, and at Keokuk, Iowa, on March 3. Navigation was opened at Keokuk on March 15, and on Lake Pepin on March 24, the latter date said to have been the earliest on record. The lowest point at which ice was observed was at Chester, Ill., where there was some floating ice on March 2. Missouri River at Bismarck, on March 13, and Omaha on March 4. Red River of the North at Wahpeton, N. Dak., on March 7; Moorhead, Minn., on March 19, and Pembina, N. Dak., March 28.

Navigation on the Hudson River was opened on March 17, and at Hartford, Conn., on the Connecticut River, on March 8. The ice went out at Bellows Falls, Vt., on March 26, but the Penobscot River was not open throughout its entire length until March 27, although the ice went out at Mattawamkeag, Me., on March 8.

All dates were unusually early owing to the high temperature of the month.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SPECIAL PAPERS ON GENERAL METEOROLOGY.

COMMENTS ON PROFESSOR SWAIN'S ARTICLE ON FLOODS AND FORESTS.

(In American Forestry, April, 1910.)

By THOMAS P. ROBERTS, United States Engineer Office, Pittsburg, Pa.

The underlying motive of Professor Swain's argument in the Engineering News of April 14 is to connect the forest problem with the navigability of rivers and hence the questions involved are of considerable national importance. The position of the "foresters," of which body Professor Swain is a prominent representative, may be briefly stated as follows, to wit:

First. The forests, especially on the mountain slopes about the headwaters of the streams, tend to equalize the discharge of water from rains and melted snow restraining the floods on navigable rivers, and at the same time increasing their low water discharge from reserves of ground storage.¹

Against this proposition some of the engineers engaged on river improvements contend that observations of river gage records and calculations of stream discharge lend but little, if indeed any, support to the theories of the foresters. Among other things it is contended that the per cent of rainfall discharged by the rivers during the winter or flood months, indicates, at least for most of the Ohio Valley, but a limited contribution to ground storage during that time and that this storage capacity is usually taxed to its utmost limit before the close of winter, and hence its restraining influence would seldom be of any importance. It must be the case that the line of permanently saturated soil and rock on great areas is much nearer the surface than it is commonly thought to be. This is undoubtedly the case where short-lived "wet weather" springs abound, the most prolific of which cease to flow in a few hours after the storms have passed.

Second. On the part of the foresters it is claimed that the destruction of forests leads to such soil waste or erosion about the headwaters as to result in the silting up of the beds of our navigable streams and thus to interference with traffic upon them.

Against this it is replied that on the Ohio at least, by reason of the greatly diminished number of snags and the effect of training works constructed by the Government at occasional points, there is much less silting than formerly, and that in con-

sequence the navigable depth is somewhat better and very much safer. With the reduction in numbers of snags and tree trunks, which, in old times, formed the nucleus of sand bars, the force of the flood currents tends to create and maintain a more uniform cross section with less undermining of the banks and consequently greater stability of shore bars. Speaking of the San Francisco River in Brazil the late W. Milnor Roberts, C. E., said the permanent shore and other bars were a distinct advantage to the navigation of the stream by contracting the discharge in wide places and thus, with a given volume of water, increasing the navigable depth. The present writer, whose experience on western rivers dates from 1866, and who is very familiar with the stories of pilots extending back to 1837, takes this occasion to emphasize the statement that the Ohio is greatly improved over its old-time conditions in every respect. Regarding the Ohio's low water discharge, certain United States Indian Commissioners, in 1785, reported such tributaries as the Little Miami, 1,800 square miles drainage area, near where Cincinnati has since grown up, so low that there was no water visible flowing from it into the Ohio.² The figures of measured discharge, reported by Col. Charles Ellett at Wheeling, and Major Sanders at Pittsburg, in 1838, were as low as the discharge for 1908. The year 1854 is thought to have been about the same as 1838 and 1908, but the actual minimum discharge was not obtained in 1854. Also, regarding high water discharges, attention is invited to Judge Hugh Brackenridge's (afterwards Chief Justice of Pennsylvania) account, published in 1786 in the Pittsburg Gazette, of a flood in the Allegheny scouring away the river bank near Fort Pitt, totally destroying a long row of houses with their gardens. Viewing these extremes, it is difficult to believe that the operations of man during the past century have resulted in any detriment to the river.

Professor Swain admits, and it should be generally understood, that grave doubts are entertained by some of our national legislators as to the right of Congress to authorize expenditures for the purchase of land and reforestation same unless it can be clearly shown that such expenditures will result in a benefit to the public and made necessary for the improvement of inland navigation.

¹ To amount to anything for the benefit of open river navigation, the volume of such reserve water must be very great.

² The commissioners reported that their flat boats were frequently aground on the shoals, which were as bad below Wheeling as above that point.